SOLVAY CHEMICAL, INC.
GREEN RIVER, WYOMING

CALCINERS 1 AND 2 COMMON STACK
HYDROGEN FLUORIDE EMISSIONS REPORT

Report submitted on May 30, 2013 to:

Mr. Tim Brown
Environmental Services Supervisor
Solvay Chemicals, Inc.
20 Miles West of Green River
Green River, WY 82935

Report Prepared by:

Optimal
AIR TESTING SERVICES, INC

*9971 Landmark Lane
Casper, Wyoming 82604
(307) 237-0814*

We certify that we have examined the information submitted in this report
and believe the results presented are true, accurate, and complete.

Daniel Klassen

Daniel Klassen   Justin Russell
President   Quality Control

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1.0 PROJECT OVERVIEW

Solvay Chemicals, Inc. Plant (Solvay) contracted Optimal Air Testing Services, Inc. (Optimal) to complete air emissions testing. Emissions of hydrogen fluoride from the Calciners 1 & 2 common stack were measured for compliance purposes. *The Calciner 1 & 2 common stack is also referred to as "CA - 1 & 2" and Calciner Stack "CA- A & B" common stack.* Test program results are summarized below.

Testing was coordinated by Tim Brown and Ouisha Toenyes, Solvay and Mr. Dan Klassen, Optimal. Testing followed procedures set forth in the <u>Code of Federal Regulations</u>, Title 40 (40 CFR), Part 51, Appendix M and Part 60, Appendix A.

The scope of work was to complete three runs simultaneously measuring flow rate and hydrogen fluoride emissions. Parameters measured to calculate flow rate include velocity, temperature and concentrations of moisture, oxygen (O_2) and carbon dioxide (CO_2). Average results for the three run, summarized below in Table 1, were based on the laboratory limit as hydrogen fluoride was not detected in the samples. Test parameters for each run are detailed in Section 2, Table 3.

Field data recorded on-site, attached in Appendix A, was entered into spreadsheets and used to calculate results, as shown in Appendix B. Equipment calibrations are attached in Appendix C. Example equations are presented in Appendix D and laboratory data is included in Appendix E.

Table 1 CA - 1 & 2 Summary of Hydrogen Fluoride Test Results, Solvay, April 19, 2012

Parameter / Pollutant	EPA Method	Units	Measured Results (average)
Stack Gas Temperature	2	°F	401
Stack Gas Moisture	4	%	23.47
Oxygen (O_2) Carbon Dioxide (CO_2)	3A	%	13.30 9.30
Flow Rate	1-4	acfm dscfm	388,443 144,077
HF Concentration in Gas	26A	gr/dscf lb/hr lb/ton of coal	<0.00004 <0.049 <0.0044

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2.0 SUMMARY OF RESULTS

Table 2 CA - 1 & 2 Hydrogen Fluoride Test Parameters and Results, Solvay, April 19, 2013

	Start Date/Time	4/19/13 10:44	4/19/13 12:25	4/19/13 14:08	
	Stop Time	12:11	13:58	15:30	
Coal Consumption	**Units**	**Run 1**	**Run 2**	**Run 3**	-
AQD #17 "A" Calciner	TPH	5.6	5.6	5.6	
AQD #17 "B" Calciner	TPH	5.6	5.6	5.6	
Combined Coal Consumption	TPH	11.2	11.2	11.2	
Test Parameters	**Units**	**Run 1**	**Run 2**	**Run 3**	**Avg.**
P_{bar} (Barometric Pressure, absolute)	In. Hg	23.70	23.70	23.70	
Y (Dry Gas Meter Calibration Factor)	unitless	0.992	0.992	0.992	
C_p (Pitot tube Coefficient)	unitless	0.84	0.84	0.84	
D_n (Diameter of Nozzle)	Inches	0.304	0.304	0.304	
θ (Total Sampling Time of Test)	Minutes	80	80	80	
ΔH (Orifice Pressure Drop)	In. H2O	1.87	1.94	2.04	
V_m (Dry Gas Sampled - as measured)	ft^3 (dry)	61.435	63.796	66.612	
T_m (Gas Meter Temperature, avg.)	Degr. F	83	87	87	
V_{lc} (Condensate and silica gel)	ml or g	306.5	316.6	330.8	
Location/Process Parameters					
A_s (Cross-sectional Area of Stack)	ft^2	113.1	113.1	113.1	113.1
P_g (Static Pressure of Stack Gas)	In. H2O	-0.60	-0.61	-0.60	-0.60
T_s (Temperature of Stack Gas)	Deg. F	401	400	402	401
√Δp (Sq. root of velocity head of gas)	√ In. H2O	0.6902	0.6829	0.6940	0.6890
CO_2 (Carbon Dioxide)	%	9.4	9.4	9.0	9.3
O_2 (Oxygen)	%	13.0	13.4	13.4	13.3
Calculations					
V_{mstd} (Gas Sampled, standard (std) cond.)	ft^3	47.17	48.68	50.78	48.88
V_{wstd} (Water Vapor in Gas Sampled, std)	ft^3	14.45	14.93	15.60	14.99
B_{ws} (Water Vapor in Gas, by Vol.)	%	23.45	23.47	23.50	23.47
M_d (Molecular Weight of Dry Stack Gas)	lb/lb-mole	30.02	30.04	29.98	30.01
M_s (Molecular Weight of Wet Stack Gas)	lb/lb-mole	27.20	27.21	27.16	27.19
P_s (Pressure of Stack Gas, Absolute)	In. Hg	23.66	23.66	23.66	23.66
Iso (Percent of Isokinetic Sampling)	%	91.7	95.6	98.2	95.2
Flow Results					
V_s (Average Stack Gas Velocity)	ft/m (fpm)	3,440	3,400	3,464	3,435
Q_a (Actual Volumetric Flow Rate)	ft^3/m (cfm)	389,040	384,540	391,750	388,443
Q_{std} (Dry Volumetric Flow Rate, std.)	ft^3/m (dscfm)	144,340	142,850	145,040	144,077
HF Results		-	-	-	
Mass of HF Collected	mg/sample	<0.123	<0.126	<0.128	
HF Concentrations in gas - std.	mg/m^3 gas	<0.092	<0.094	<0.096	
HF Concentrations in gas - std.	gr/dscf	<0.00004	<0.00004	<0.00004	
HF Concentrations in gas	ppm	<0.111	<0.113	<0.115	<0.113
HF Emission Rate (Coal Fd = 9780)	lb/mmBtu	<1.5E-04	<1.6E-04	<1.5E-04	<1.5E-04
HF Emission Rate	lb/hr	<0.050	<0.049	<0.048	<0.049
HF Emission Rate	lb/ton of coal	<0.0044	<0.0044	<0.0043	<0.0044

3.0 PROCESS DESCRIPTION

Solvay Chemicals, Inc., located near Green River, Wyoming, is a trona mine and refinery with corporate offices in Houston, Texas.

The primary raw material for the Green River facility is sodium sesquicarbonate, commonly referred to as trona. The trona is mined at the plant site from an ore bed located 1,500 feet below the surface. The trona is hoisted to the surface before refining into soda ash and other sodium-based products.

The trona that is fed to the soda ash calciners is heated, resulting in thermal calcinations of the sodium sesquicarbonate forming a crude soda ash. The crude soda ash is dissolved in water and the insolubles are separated from the solution by settling and filtration. The insolubles are disposed of in the mine void. The high-purity saturated solution of sodium carbonate is then fed to crystallizers where a large amount of water is removed and a slurry of sodium carbonate monohydrate crystals is formed. This slurry is then further dewatered and washed by a series of cyclones and centrifuges. The resulting monohydrate crystals are fed through dryers forming a high quality soda ash, which then is ready for storage and shipment.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Optimal Air Testing Services, Inc. collected source data and samples of gas from the CA - 1 & 2 exhaust stack under the roof (inside building). Sampling activities were performed in accordance with standard EPA sampling methods listed in 40CFR51, Appendix M and 40CFR60, Appendix A. The parameters and pollutants measured during the sampling program are listed below with brief descriptions of the sampling methods.

- **Traverse to measure velocity head and temperature.** Method 1 was used to calculate the points (location) in the stack for sampling. Method 2 procedures were followed to measure stack gas velocity and temperature in conjunction with particulate sampling.

Table 3 CA - 1 & 2 Stack Dimensions and Traverse Points, Solvay

CA - 1 & 2 Stack Configuration	Vertical – circular
Test Location	Stack
Measured Inside Stack Diameter	144 inches
Port Length	Port A – 9.0 inches Ports B, C and D – 9.5 inches
Distance from ports upstream to disturbance	~66 feet (~5.5 diameters)
Distance from ports downstream to disturbance	~80 feet (~6.7 diameters)
No. of Ports	4
Velocity/temp./Particulate traverse points	20 (5 per port)
Point #1	$3\,^3/_4$ (probe mark at $13\,^1/_4$)
Point #2	$11\,^{13}/_{16}$ (probe mark at $21^5/_{16}$)
Point #3	21 (probe mark at $30\,^1/_2$)
Point #3	$32\,^9/_{16}$ (probe mark at $42\,^1/_{16}$)
Point #4	$49\,^1/_4$ (probe mark at $58\,^3/_4$)

- **Oxygen, Carbon Dioxide and Molecular Weight.** Stack gas molecular weight was calculated from oxygen and carbon dioxide concentrations measured from a gas sample collected during each run. O_2 and CO_2 concentrations were measured in accordance with 40 CFR 60 Method 3A (instrument analyzers) in conjunction with the NOx sampling, as described below.

- **Moisture.** Stack moisture measurements was calculated from the volume of moisture that condensed out of a measured volume of exhaust gas collected following 40 CFR 60 Method 4. Moisture was measured in conjunction with particulate sampling.

- **Flow Rate.** Stack gas flow rate was calculated for each run from the velocity, molecular weight, and moisture content determined via Methods 1 through 4.

- **Hydrogen Halogens and Halides.** Samples were collected isokinetically in accordance with 40 CFR 60, Method 26A and analyzed for HCl.

4.1 Temperature, Velocity, Moisture and Flow Rate

Method 1-4 procedures were used to select sampling locations, operate the sampling train, record data, and calculate flow rate in conjunction with the isokinetic hydrogen fluoride sampling trains.

Stack samples were collected from five points in each of the four ports, for a total of twenty points. The sampling point locations for the stack are listed in Table 3.

Sampling equipment was calibrated at the Optimal's laboratory prior to job mobilization. Equipment calibrations are included in Appendix C.

The velocity sampling apparatus consisted of S-type stainless steel pitots used to measure velocity head (pressure) and a thermocouple to measure temperature. Tubing connected the pitot tubes to an inclined manometer. The velocity apparatus was leak checked before and after each run.

Moisture concentration was determined by drawing a measured volume of the stack gas through chilled impingers. Moisture condensed in the impingers as the gas was cooled below 68°F. The total weight gain of the impingers and the volume of gas were measured to calculate the moisture concentration in the stack gas. The sampling train was checked for leaks before and after each run.

4.2 Hydrogen Halides and Halogens

EPA Methods 26A was used to determine hydrogen fluoride (HF) concentrations at the test location. A sample of the gas stream was withdrawn from the source isokinetically. The HF was collected in a solution of 0.1 N sulfuric acid (H_2SO_4). Hydrogen fluoride analysis was by ion chromatography.

Pretest Preparation
All glassware was cleaned with detergent and rinsed with tap water. Then all glassware was cleaned with 0.1 N H_2SO_4, distilled water and acetone prior to shipment to the test location. The meter, thermometers, and pitot tube were calibrated prior to shipment. Sampling nozzles were calibrated on site.

Apparatus
The probe nozzle was made of borosilicate glass of buttonhook design with a taper angle of less than 30°. The probe was constructed of borosilicate glass and equipped with a heater capable of maintaining a constant temperature above 248°F ± 25°F for the test duration, to prevent moisture condensation in the probe. The probe was equipped with a pitot tube for constant monitoring of the stack gas velocity and a thermocouple accurate to within ± 2°F to measure the stack gas temperature. The filter holder was made of borosilicate glass with a Teflon support and a Teflon coated viton gasket to provide a positive seal. A filter heating system capable of maintaining a temperature above 248°F ± 25°F and a thermocouple accurate to within ± 2°F were utilized. The metering system included: a vacuum gauge, leak free pump, thermometers accurate to within ± 5.4°F and a dry gas meter accurate to within 2 percent. Differential pressure gauges were used, one to measure stack gas velocity and the other for orifice differential pressure readings. The first and second impingers contained 100-ml of 0.1 N H_2SO_4, the third was empty, and the fourth impinger contained a tare weighted quantity of silica gel.

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Reagents

Teflon filters with 99.95% efficiency, <0.05% penetration, on 0.3-micron dioctyl phthalate smoke particles were used. Acetone, distilled water, and 0.1 N H_2SO_4 of reagent grade were used.

Sampling

The sample points were selected according to procedures outlined in EPA Method 1. The stack pressure, temperature, and velocity heads were determined using EPA Method 2. The nozzle size was selected for isokinetic sampling based upon the velocity head range.

The sample train was assembled using ball joint style glassware with Teflon coated o-rings on the joints to ensure a leak free seal. The impingers were placed in an ice bath for the duration of the test.

The entire sampling train was leak checked and had <0.02-cfm leakage prior to any sampling. The probe was placed in the stack and the system allowed to heat up. The sampling commenced when the probe and filter reached sampling temperature. Sampling time was increased to 80 minutes in order to reduce the detection limit.

After the test, the sample train was leak checked. The leakage was less than the maximum allowable amount (0.02 cfm or 4% of the average sampling rate) and test results were considered allowable.

Sample Recovery

A 100-ml of acetone, a 100-ml sample of the 0.1 N H_2SO_4, and a 200-ml sample of distilled water were taken as reagent blanks. The tared drying column (silica gel) was removed and weighed, the weight gain of the desiccant recorded and used in the moisture calculations. The impinger catch was weighed on top loader balance to determine the weight to the nearest 0.5 gram, which was used in the moisture calculation. The 0.1 N H_2SO_4 impinger contents were recovered and placed into a 500-ml glass sample jar with a Teflon lined lid. The connecting glassware and the two acid impingers were rinsed with distilled water and combined with the acid impinger contents. The liquid levels were marked for transportation to the laboratory.

Analysis

The hydrogen fluoride was analyzed by ion chromatography.

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APPENDIX A

FIELD DATA

Source Testing Field Data Sheet for Hydrogen Fluoride   Methods 1-5/26A   Run 1   Page 1 of 1

| Client: Solvay Chemical |
| Plant: Green River |
| Test Location: Calciner |
| Unit: CA 1 & 2 (aka CA-A & B) |
| Project No.: 1301A |
| Meter Operator: T Russell |
| Assistant: O Klassen |

Nozzle Calibration

1st Dia.	0.303
2nd Dia.	0.304
3rd Dia.	0.304

Meter ID	4
Meter Y	0.992
Meter ΔH@	2.008
Pitot ID	P-4-2
Pitot Cp	0.84
Probe Liner	Class
Nozzle ID	Glass
Nozzle Size	0.304
Sample Time	80
% CO₂	9.4
% O₂	13.0

Date:	8 4/19/13
Ambient Temp. °F:	80
Bar. Pressure in. Hg:	
Static Press. in. H₂O	+0.53
Assumed % Moist	
K Factor	3.9
Duct Dimensions: 144 inches	
Port Length: 35 inches 9.5	
Pitot Passes Leak Checks:	
Pretest ☐ Posttest ☑	
1st Point all the way In ☐ Out ☐	

Filter NA (Teflon) Inside Building

Diluent Analysis by CEMS ☐

Impinger Weight

	Pretest (g)	Post test (g)	Total (g)	Vol. (ml)	Style*	Contents
1	746.8	746.91.3 745	745	~100	MGS*	0.1N H₂SO₄
2	756.7	984.6	97.9	~100	GS*	0.1N H₂SO₄
3	658.4	655.0	2.6	—	MGS*	
4	939.2	937.7	96.7	~300g	MGS*	Silica Gel
5			396.5			

	CO₂	CO₂+O₂	O₂
1st Orsat	9.4	22.4	13.0
2nd Orsat			

Leak Rates/Notes 0.003

Pre-test 9 in Hg 0.00 cfm.
Post-test 9 in Hg 0.003 cfm

K factor 3.8

Traverse Point (Port-Pt)	Time (minutes) 0	Velocity Head (Δp, in. H₂O)	Orifice Setting (ΔH, in. H₂O)	Gas Meter ft³	Stack	Temperature, °F Impinger Outlet	Gas Meter Inlet	Gas Meter Outlet	Probe	Filter	Pump Vacuum (in. Hg)
D -5	1044 4	0.51	3.0	688.765	409	60	80	79	261	477	4.5
-4	8	0.52	3.0	691.83	409	63	76	79	295	326	5.5
-3	12	0.51	2.0	694.97	411	58	75	79	262	260	5.5
-2	16	0.47	1.7	698.1	412	59	79	79	279	264	5.5
-1	1104 20	0.35	1.4	701.07	410	60	79	79	269	263	5.5 5.0
C -5	1106 24	0.50	2.6	203.846	451	63	81	79	258	261	5.0
-4	28	0.55	2.2	706.87	408	63	82	81	251	261	7.0
-3	32	0.60	3.3	710.19	401	64	85	80	251	260	7.5
-2	36	0.56	3.2	713.59	402	67	85	80	270	261	7.5
-1	1130 40	0.4	1.8	716.95	400	66	87	81	260	261	7.0
B -5	1132 44	0.47	1.8	720.024	393	67	86	83	274	263	6.0
-4	48	0.45	1.8	723.69	393	65	89	82	295	255	6.0
-3	52	0.45	1.8	726.13	392	64	89	83	297	258	6.0
-2	56	0.44	1.7	729.14	391	62	89	84	271	259	6.0
-1	1149 60	0.37	1.4	732.13	391	61	90	85	261	261	5.5
A -5	1151 64	0.57	2.0	734.843 739.05	403	60	89	84	265	262	7.0
-4	68	0.53	2.0	741.23	402	58	90	84	266	260	7.0
-3	72	0.57	2.2	744.51	401	57	89	84	256	259	7.5
-2	76	0.52	2.0	747.91	401	58	88	85	250	260	7.5
-1	80	0.27	1.0	750.200	395	34	89	84	350	259	5.0
Avg /Total											

Optimal Air Testing

Source Testing Field Data Sheet for Hydrogen Fluoride Methods 1-5/26A Run 2

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10400 Ft

Client: Solvay Chemical	Meter ID 4
Plant: Green River	Meter Y 0.992
Test Location: Calciner	Meter ΔH@ 2.008
Unit: CA 1 & 2 (aka CA-A & B)	Pitot ID P-4-2
Project No.: 1301A	Pitot Cp 0.84
Meter Operator: J Rossey	Probe Liner Glass
Assistant: D Klassen	Nozzle ID Glass

Nozzle Calibration
1st Dia. ___ see Run1
2nd Dia. ___
3rd Dia. ___

| Date: 4/11/13 |
| Ambient Temp. °F: 82 |
| Bar. Pressure in. Hg: 23.7 |
| Static Press. in. H₂O + 0.01 |
| Assumed % Moist |
| K Factor 3.8 |
| Duct Dimensions: 144 inches |
| Port Length: 3.5 inches 9.5 |
| Nozzle Size 0.304 |
| Sample Time 60 |
| % CO₂ 9.4 |
| % O₂ 13.4 |

Filter Teflon — inlet
root
Diluent Analysis ☐
by CEMS ☐

Pitot Passes Leak Checks:
Pretest ☑ Posttest ☐
1st Point all the way In Out

Impinger Weight

	Pretest (g)	Post test (g)	Total (g)	Vol. (ml)	Style*	Contents
1	751.4	975.6	224.2	~100	MGS*	0.1N H₂SO₄
2	629.3	701.3	72.0	~100	GS*	0.1N H₂SO₄
3	656.2	662.8	6.6	—	MGS*	
4	907.7	921.5	13.8	~300g	MGS*	Silica Gel
5			316.6			

	CO₂	CO₂+O₂	O₂
1st Orsat	9.4	22.8	13.4
2nd Orsat			

Leak Rates/Notes
Pre-test 1 in Hg 0.005 cfm.
Post-test 9.5 in Hg 0.003 cfm

K factor 4.7

5 to 2.54

Optimal Air Testing

Traverse Point (Port-Pt)		Time (minutes) 0	Velocity Head (Δp, in. H₂O)	Orifice Setting (ΔH, in. H₂O)	Gas Meter ft³	Temperature, °F Stack	Impinger Outlet	Gas Meter Inlet	Gas Meter Outlet	Probe	Filter	Pump Vacuum (in. Hg)
0	-5	1225 4	0.53	3.0	750.407	391	59	86	85	301	363	5.0
	-4	8	0.53	3.0	753.63	399	50	85	84	309	361	6.0
	-3	12	0.54	3.1	756.95	400	50	89	85	319	360	6.0
	-2	16	0.47	1.8	760.18	396	49	89	84	322	362	5.5
	-1	1245 20	0.34	1.3	763.31	395	50	88	84	318	361	4.5
C	-5	1249 24	0.47	2.0	765.962	382	52	90	84		257	5.5
	-4	28	0.43	1.8	769.16	390	49	89	85	244	255	5.5
	-3	32	0.42	1.8	772.38	391	51	90	84	250	251	5.5
	-2	36	0.41	1.7	775.36	391	52	90	84	256	258	5.5
	-1	1309 40	0.33	1.4	778.43	383	52	91	85	234	259	5.0
B	-5	1310 44	0.50	2.1	781.176	383	53	89	85	252	266	6.0
	-4	48	0.53	2.2	784.47	402	41	90	85	281	261	7.0
	-3	52	0.58	2.4	787.91	404	48	92	85	273	258	7.5
	-2	56	0.59	2.5	791.47	404	51	89	85	366	261	7.5
	-1	1330 60	0.41	1.7	795.05	402	49	91	85	259	260	6.0
A	-5	1334 64	0.51	2.1	798.293	410	54	86	84	341	259	7.0
	-4	68	0.50	2.1	801.42	410	47	87	84	300	264	7.0
	-3	72	0.51	2.1	804.76	412	49	89	84	300	367	7.0
	-2	76	0.47	2.0	808.12	416	47	90	85	289	258	7.0
	-1	60	0.33	1.4	811.41	416	51	90	83	371	360	5.0
Avg/Total					814.303							

Source Testing Field Data Sheet for Hydrogen Fluoride   Methods 1-5/26A   Run 3

Client: Solvay Chemical
Plant: Green River
Test Location: Calciner
Unit: CA 1 & 2 (aka CA-A & B)
Project No.: 1301A
Meter Operator: J Russell
Assistant: D Klassen

Nozzle Calibration

1st Dia.	—
2nd Dia.	— see Run 1
3rd Dia.	—

Meter ID	4
Meter Y	0.997
Meter ΔH@	2.803
Pitot ID	P-4.2
Pitot Cp	0.84
Probe Liner	Glass
Nozzle ID	Glass
Nozzle Size	0.304
Sample Time	80
% CO₂	9.0
% O₂	13.4

Date: 4/19/13
Ambient Temp. °F: 92
Bar. Pressure in. Hg: 23.7
Static Press. in. H₂O + @ 0.60
Assumed % Moist
K Factor 4.7
Duct Dimensions: 144 inches
Port Length: 3.5 inches 9.5
Pitot Passes Leak Checks:
Pretest ☑ Posttest ☑
1st Point all the way (In) Out

Filter Teflon

Diluent Analysis
by CEMS ☐

Impinger Weight / Impinger

	Pretest (g)	Post test (g)	Total (g)	Vol. (ml)	Style*	Contents
1	762.2	992.2	230.0	~100	MGS*	0.1N H₂SO₄
2	798.1	869.6	51.5	~100	GS*	0.1N H₂SO₄
3	657.8	665.8	6.0	—	MGS*	
4	963.6	976.9	13.3	(~300)	MGS*	Silica Gel
5			330.8			

	CO₂	CO₂+O₂	O₂
1st Orsat	9.0	22.4	13.4
2nd Orsat			

Traverse Point (Port-Pt)		Time (minutes)	0	Velocity Head (Δp, in. H₂O)	Orifice Setting (ΔH, in. H₂O)	Gas Meter ft³	Stack	Temperature, °F Impinger Outlet	Gas Meter Inlet	Gas Meter Outlet	Pump Vacuum (in. Hg)	Probe	Filter
AD	-5	1408	4	0.53	2.2	817.357	411	103	87	85	7.5	365	359
	-4		8	0.49	3.1	817.83	411	57	89	84	7.5	328	365
	-3		12	0.53	2.2	824.33	413	53	89	84	7.5	325	363
	-2		16	0.45	1.9	824.67	413	56	90	85	7.0	399	361
	-1	1729	20	0.34	1.4	827.90	412	54	90	95	5.0	387	360
C	-5	1430	24	0.50	2.1	830.484	402	55	84	85	7.0	362	364
	-4		28	0.54	2.3	834.03	402	52	90	84	8.0	370	361
	-3		32	0.59	2.5	837.57	403	51	90	85	8.5	363	360
	-2		36	0.60	2.5	841.33	403	48	91	84	8.5	359	260
	-1	1450	40	0.47	2.0	844.93	403	49	90	85	7.5	356	359
B	-5	1452	44	0.47	2.0	848.234	397	50	91	84	7.5	349	354
	-4		48	0.45	1.9	851.57	394	48	90	85	7.0	305	359
	-3		52	0.45	1.8	854.83	394	48	90	84	7.0	347	359
	-2		56	0.44	1.8	858.06	394	50	91	85	7.0	382	359
	-1	1512	60	0.35	1.5	861.21	390	50	91	86	6.0	321	367
A	-5	1514	64	0.52	2.2	864.090	393	51	91	85	7.5	359	363
	-4		68	0.53	2.2	867.47	401	52	91	85	7.5	381	360
	-3		72	0.56	2.4	870.94	402	51	91	85	9.0	372	360
	-2		76	0.52	2.2	874.56	400	53	90	84	8.5	364	260
	-1	1534	80	0.35	1.5	878.05	402	55	90	84	9.0	361	361
Avg /Total				0.35	1.5	880.969	397	57	91	85	6.5	355	361

Leak Rates/Notes

Pre-test ___ T ___ in Hg 0.005 cfm.

Post-test ___ T ___ in Hg 0.000 cfm

Optimal Air Testing

APPENDIX B

DATA ENTRY/DATA REDUCTION SPREADSHEETS

Hydrogen Fluoride Sampling Data

Method 26A

4/19/13

Optimal AIR TESTING SERVICES, INC

Run 1

Solvay Chemical	Meter ID:	4		% CO_2	9.4
Source: CA - 1 & 2	Meter Y:	0.992		% O_2	13.0
Test Location: Verical Stack (inside	Meter ΔH@:	2.008	Total Sample Minutes:		80.0
OATS Project No. 1301A	Pitot ID:	P-4-2	Sample Minutes/Point:		4.0
Technician: D. Klassen, J. Russell	Pitot Cp:	0.84	Barometric Pres., (in Hg):		23.70
Moisture Data	Nozzle ID:	glass	Static Pressure (In. H_2O):		-0.60
Impinger Pretest Posttest Total	Nozzle Dia:	0.304	Dimensions (in)		144.0
1 746.8 901.3 154.5			Area (ft^2):		113.097
2 786.7 884.6 97.9			Filter:		Teflon
3 658.4 688.0 29.6			Moisture		23.5%
4 939.2 963.7 24.5					
Sum 306.5					

Sampling Traverse Port	Point	Time Minutes 10:44	Velocity Head, Δp (in H2O)	Orifice Setting (ΔH, in H2O)	Gas Meter (ft^3) 688.765	Temperatures Stack	Gas Meter Inlet	Outlet	% Iso
D	5	10:48	0.51	2.0	691.83	409	80	79	89
	4	10:52	0.52	2.0	694.97	409	76	79	91
	3	10:56	0.51	2.0	698.11	411	75	79	92
	2	11:00	0.44	1.7	701.07	412	78	79	93
	1	11:04	0.35	1.4	703.846	410	79	79	97
	Re-Start	11:06			703.846				
C	5	11:10	0.50	2.0	706.87	401	81	79	88
	4	11:14	0.55	2.2	710.19	402	82	79	93
	3	11:18	0.60	2.3	713.59	401	85	81	90
	2	11:22	0.56	2.2	716.95	402	85	80	92
	1	11:26	0.46	1.8	720.024	400	87	80	93
	Re-Start	11:28			720.024				
B	5	11:32	0.47	1.8	723.09	393	86	83	91
	4	11:36	0.45	1.8	726.12	393	89	82	92
	3	11:40	0.45	1.8	729.18	392	89	83	93
	2	11:44	0.44	1.7	732.13	391	89	84	90
	1	11:48	0.37	1.4	734.84	391	90	85	90
	Re-Start	11:51			734.84				
A	5	11:55	0.53	2.0	738.05	403	89	84	90
	4	11:59	0.53	2.0	741.23	402	90	84	89
	3	12:03	0.57	2.2	744.59	401	89	84	91
	2	12:07	0.52	2.0	747.81	401	90	85	91
	1	12:11	0.27	1.0	750.20	395	89	84	93
Total/Avg			1.87	61.435		401			

Hydrogen Fluoride Sampling Data
Method 26A

4/19/13

Run 2

Optimal
AIR TESTING SERVICES, INC

Solvay Chemical	Meter ID:	4		% CO_2	9.4
Source: CA - 1 & 2	Meter Y:	0.992		% O_2	13.4
Test Location: Verical Stack (insi	Meter ΔH@:	2.008		Total Sample Minutes:	80.0
OATS Project No. 1301A	Pitot ID:	P-4-2		Sample Minutes/Point:	4.0
Technician: D. Klassen, J. Russell	Pitot Cp:	0.84		Barometric Pres., (in Hg):	23.70
Moisture Data	Nozzle ID:	glass		Static Pressure (In. H_2O):	-0.61
	Nozzle Dia:	0.304		Dimensions (in)	144.0

Moisture Data

Impinger	Pretest	Posttest	Total
1	751.4	975.6	224.2
2	629.3	701.3	72.0
3	656.2	662.8	6.6
4	907.7	921.5	13.8
Sum			316.6

Area (ft^2):	113.097
Filter:	Teflon
Moisture	23.5%

Sampling Traverse		Time Minutes	Velocity Head, Δp	Orifice Setting	Gas Meter (ft^3)	Temperatures	Gas Meter		%
Port	Point	12:25	(in H2O)	(ΔH, in H2O)	750.407	Stack	Inlet	Outlet	Iso
A	5	12:29	0.53	2.0	753.63	391	86	85	90
	4	12:33	0.53	2.0	756.85	399	85	84	91
	3	12:37	0.54	2.1	760.18	400	89	85	93
	2	12:41	0.47	1.8	763.31	396	89	84	93
	1	12:45	0.34	1.3	765.962	395	89	84	93
	Re-Start	12:50			765.962				
B	5	12:54	0.47	2.0	769.16	382	90	84	95
	4	12:58	0.43	2.2	772.38	390	89	85	100
	3	13:02	0.42	1.8	775.36	391	90	84	94
	2	13:06	0.41	1.7	778.43	391	90	84	98
	1	13:10	0.33	1.4	781.176	383	91	85	97
	Re-Start	13:13			781.176				
C	5	13:17	0.50	2.1	784.47	402	89	85	96
	4	13:21	0.53	2.2	787.91	402	90	85	97
	3	13:25	0.58	2.4	791.47	404	92	86	96
	2	13:29	0.58	2.4	795.05	403	89	85	97
	1	13:33	0.41	1.7	798.09	402	91	85	97
	Re-Start	13:38			798.093				
D	5	13:42	0.51	2.1	801.420	410	86	84	96
	4	13:46	0.50	2.1	804.76	413	87	84	98
	3	13:50	0.51	2.1	808.12	412	89	84	97
	2	13:54	0.47	2.0	811.41	415	90	85	99
	1	13:58	0.33	1.4	814.203	412	90	85	100
Total/Avg			1.94		63.796	400			96

Hydrogen Fluoride Sampling Data

Method 26A

4/19/13

Run 3

Solvay Chemical	Meter ID:	4	% CO$_2$	9.0
Source: CA - 1 & 2	Meter Y:	0.992	% O$_2$	13.4
Test Location: Verical Stack (inside	Meter ΔH@:	2.008	Total Sample Minutes:	80.0
OATS Project No. 1301A	Pitot ID:	P-4-2	Sample Minutes/Point:	4.0
Technician: D. Klassen, J. Russell	Pitot Cp:	0.84	Barometric Pres., (in Hg):	23.70
Moisture Data	Nozzle ID:	glass	Static Pressure (In. H$_2$O):	-0.60
	Nozzle Dia:	0.304	Dimensions(in)	144.0

Impinger	Pretest	Posttest	Total
1	762.2	992.2	230.0
2	788.1	869.6	81.5
3	659.8	665.8	6.0
4	963.6	976.9	13.3
	Sum		330.8

Area (ft^2):	113.097
Filter:	Teflon
Moisture	23.5%

Sampling Traverse Port	Point	Time Minutes	Velocity Head, Δp (in H2O)	Orifice Setting (ΔH, in H2O)	Gas Meter (ft^3)	Temperatures			% Iso
						Stack	Gas Meter Inlet	Outlet	
		14:08			814.357				
A	5	14:12	0.53	2.2	817.83	411	87	85	98
	4	14:16	0.49	2.1	821.22	411	89	84	100
	3	14:20	0.53	2.2	824.67	413	89	86	98
	2	14:24	0.45	1.9	827.900	413	90	85	99
	1	14:28	0.34	1.4	830.684	412	90	85	98
	Re-Start	14:30			830.684				
B	5	14:34	0.50	2.1	834.03	402	89	85	97
	4	14:38	0.54	2.3	837.57	403	90	84	99
	3	14:42	0.59	2.5	841.23	403	90	85	98
	2	14:46	0.60	2.5	844.93	403	91	86	98
	1	14:50	0.47	2.0	848.234	403	90	85	99
	Re-Start	14:52			848.234				
C	5	14:56	0.47	2.0	851.57	397	89	84	99
	4	15:00	0.45	1.9	854.83	394	90	85	99
	3	15:04	0.45	1.9	858.06	394	90	86	98
	2	15:08	0.44	1.8	861.21	392	91	85	96
	1	15:12	0.35	1.5	864.090	392	91	86	99
	Re-Start	15:14			864.090				
D	5	15:18	0.53	2.2	867.47	401	89	85	95
	4	15:22	0.53	2.2	870.94	402	91	85	97
	3	15:26	0.56	2.4	874.56	400	91	85	99
	2	15:30	0.52	2.2	878.05	402	90	84	99
	1	15:34	0.35	1.5	880.969	397	91	85	100
Total/Avg			2.04	66.612		402		87	

Hydrogen Fluoride Sampling Data

Solvay Chemical

Source: CA - 1 & 2

		Start Date/Time	4/19/13 10:44	4/19/13 12:25	4/19/13 14:08	
		Stop Date/Time	12:11	13:58	15:30	
Coal Consumption	**Units**		**Run 1**	**Run 2**	**Run 3**	
AQD #17 "A" Calciner	TPH		5.6	5.6	5.6	
AQD #17 "B" Calciner	TPH		5.6	5.6	5.6	
Combined Coal Consumption	TPH		11.2	11.2	11.2	
Test Parameters	**Units**		**Run 1**	**Run 2**	**Run 3**	**Avg.**
P_{bar} (Barometric Pressure, absolute)	In. Hg		23.70	23.70	23.70	
Y (Dry Gas Meter Calibration Factor)	unitless		0.992	0.992	0.992	
C_p (Pitot tube Coefficient)	unitless		0.84	0.84	0.84	
D_n (Diameter of Nozzle)	Inches		0.304	0.304	0.304	
θ (Total Sampling Time of Test)	Minutes		80	80	80	
ΔH (Orifice Pressure Drop)	In. H2O		1.87	1.94	2.04	
V_m (Dry Gas Sampled - as measured)	ft3 (dry)		61.435	63.796	66.612	
T_m (Gas Meter Temperature, avg.)	Degr. F		83	87	87	
V_{lc} (Condensate and silica gel)	ml or g		306.5	316.6	330.8	
Location/Process Parameters						
A_s (Cross-sectional Area of Stack)	ft2		113.1	113.1	113.1	113.1
P_g (Static Pressure of Stack Gas)	In. H2O		-0.60	-0.61	-0.60	-0.60
T_s (Temperature of Stack Gas)	Deg. F		401	400	402	401
$\sqrt{\Delta p}$ (Sq. root of velocity head of gas)	$\sqrt{}$ In. H2O		0.6902	0.6829	0.6940	0.6890
CO_2 (Carbon Dioxide)	%		9.4	9.4	9.0	9.3
O_2 (Oxygen)	%		13.0	13.4	13.4	13.3
Calculations						
V_{mstd} (Gas Sampled, standard (std) cond.)	ft^3		47.17	48.68	50.78	48.88
V_{wstd} (Water Vapor in Gas Sampled, std)	ft^3		14.45	14.93	15.60	14.99
B_{ws} (Water Vapor in Gas, by Vol.)	%		23.45	23.47	23.50	23.47
M_d (Molecular Weight of Dry Stack Gas)	lb/lb-mole		30.02	30.04	29.98	30.01
M_s (Molecular Weight of Wet Stack Gas)	lb/lb-mole		27.20	27.21	27.16	27.19
P_s (Pressure of Stack Gas, Absolute)	In. Hg		23.66	23.66	23.66	23.66
Iso (Percent of Isokinetic Sampling)	%		91.7	95.6	98.2	95.2
Flow Results						
V_s (Average Stack Gas Velocity)	ft/m (fpm)		3,440	3,400	3,464	3,435
Q_a (Actual Volumetric Flow Rate)	ft^3/m (cfm)		389,040	384,540	391,750	388,443
Q_{std} (Dry Volumetric Flow Rate, std.)	ft^3/m (dscfm)		144,340	142,850	145,040	144,077
HF Results						
Mass of HF Collected	mg/sample		<0.123	<0.126	<0.128	
HF Concentrations in gas - std.	mg/m^3 gas		<0.092	<0.094	<0.096	
HF Concentrations in gas - std.	gr/dscf		<0.00004	<0.00004	<0.00004	
HF Concentrations in gas	ppm		<0.111	<0.113	<0.115	<0.113
HF Emission Rate (Coal Fd = 9780)	lb/mmBtu		<1.49E-04	<1.56E-04	<1.51E-04	<1.52E-04
HF Emission Rate	lb/hr		<0.050	<0.049	<0.048	<0.049
HF Emission Rate	lb/ton of coal		<0.0044	<0.0044	<0.0043	<0.0044

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APPENDIX C

EQUIPMENT CALIBRATIONS

Calibrations for Meter Box 4

Full Test Meter Calibration - Critical Orifice
Technician: Gene Wintermote
1/3/2013

Run No.	1A	1B	2A	2B	3A	3B	Average
Barometric Pressure, Pb	24.90	24.90	24.90	24.90	24.90	24.90	
Calibration Orifice Coef. (K)	0.6810	0.6810	0.5560	0.5560	0.4240	0.4240	
Final Meter Reading, ft³	274.742	280.851	287.225	293.611	299.035	304.556	
Initial Meter Reading, ft³	268.597	274.742	280.854	287.225	293.611	299.035	
Total Metered Volume, ft³	6.145	6.109	6.371	6.386	5.424	5.521	
Initial Inlet Meter Temp, °F	48	50	50	51	51	52	
Final Inlet Meter Temp, °F	50	50	50	51	51	53	
Initial Outlet Meter Temp, °F	48	49	50	50	51	52	
Final Outlet Meter Temp, °F	49	50	50	51	51	52	
Average Meter Temp, °R	509	510	510	511	511	512	
Time: Minutes of Run Time	7	7	9	9	10	10	
Seconds of Run Time	0.00	0.00	0.00	0.00	0.00	0.00	
Initial Orifice pressure drop, ΔH	2.30	2.30	1.50	1.50	0.92	0.92	
Final Orifice pressure drop, ΔH	2.30	2.30	1.50	1.50	0.92	0.92	
Avg. Orifice pressure drop, ΔH	2.30	2.30	1.50	1.50	0.92	0.92	
Ambient (Orifice) Temp., °F	52	51	51	52	52	53	
Vacuum Setting, "Hg	12.0	12.0	14.0	14.0	15.5	15.5	
$V_{cr\,std}$	5.246	5.251	5.512	5.507	4.666	4.661	
Std, Volume Metered, Q_{std}, ft³	5.341	5.300	5.511	5.516	4.675	4.747	
Calibration Factor (Y)	0.982	0.991	1.000	0.998	0.998	0.982	0.992
Tolerance within allowable limits	Pass	Pass	Pass	Pass	Pass	Pass	
Orifice Cal. Factor, ΔH @	2.017	2.009	1.955	1.956	2.055	2.054	2.008
Tolerance within allowable limits	Pass	Pass	Pass	Pass	Pass	Pass	

Thermocouple Calibrations
Technician: **G. Wintermote**
Date of Calibration: **8/22/2012**

	Stack	Impinger Outlet	Dry Gas Meter Inlet	Outlet	Auxilary	Probe	Filter
Ice							
Temp. of Reference, °F	32	32	32	32	32	32	32
Thermocouple Reading, °F	32	30	32	33	30	30	32
% Difference, based on °R	0.00	0.41	0.00	-0.20	0.41	0.41	0.00
Boiling Water							
Temp. of Reference, °F	212	212	212	212	212	212	212
Thermocouple Reading, °F	211	212	213	212	212	209	213
% Difference, based on °R	0.15	0.00	-0.15	0.00	0.00	0.45	-0.15
Oil							
Temp. of Reference, °F	449	449	449	449	449	449	449
Thermocouple Reading, °F	450	449	450	448	448	447	450
% Difference, based on °R	-0.11	0.00	-0.11	0.11	0.11	0.22	-0.11

Type S Pitot Tube Inspection Data

Date: 10-Apr-13   Pitot Number: P-4-2

Pitot Tube Assembly Level?   yes   x   no

Pitot Tube Assembly Damaged?   yes   no   x
If yes explain below.

α_1 0.9   *(<10 °)* α_2 0.5   *(<10 °)*

β_1 2.1   *(<5 °)* β_2 2.8   *(<5 °)*

$\gamma =$ 0.5   ° $\theta =$ 1.6   °

$A =$ 0.735   inches

$Z = A\ SINE\ \gamma =$ 0.0064   inches   *Where Z is < 0.32 cm (<1/8 in)*

$W = A\ SINE\ \theta =$ 0.0205   inches   *Where W is < 0.08 cm (<1/32 in)*

$Pa =$ 0.376   inches $Pb =$ 0.370   inches

$P = (Pa + Pb) / 2 =$ 0.373 inches

$Dt =$ 0.25   inches $P/ Dt =$ 1.492 inches   *Where 1.05 ≤ P/Dt :*

Comments: Meets geometric calibration requirements.

Cp =   0.84

48   inch effective probe

Additional Calibration Required?   yes   no

Calibrated by: Justin Russell

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APPENDIX D

EXAMPLE EQUATIONS

Optimal
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Abbreviations and Nomenclature for Emissions Calculations

A_n — Cross sectional area of nozzle, (ft^2)

A_s — Cross sectional stack Area, (ft^2)

B_{ws} — Proportion of water vapor, by volume, in the gas stream

C_{gas} — Drift Corrected pollutant or diluent concentration on a dry basis

C_{run} — Average pollutant/diluent concentration reported by analyzer for run, dry basis

C_m — Average of initial and final system calibration bias check responses for the upscale calibration gas, ppm

C_0 — Average of initial and final system calibration bias check responses for the zero gas, ppm

C_{ma} — Actual concentration of the upscale calibration gas, ppm

CE — Calibration Error, Difference between analyzer reading and calibration gas injected directly into analyzer

CF — Cubic Feet, ft^3

CFM — Cubic Feet per Minute, ft^3/min.

C_p — Pitot Tube Coefficient, dimensionless

C_{PM} — Particulate matter concentration, corrected to standard condition, lb/dscf

D_n — Diameter of nozzle, inches (in)

D_s — Diameter of stack, ft

E_{PM} — Particulate matter emission rate, lb/hr

E_{gas} — Gaseous Pollutant emission rate, lb/hr

ΔH — Pressure Differential across meter orifice

in. Hg — Pressure, measured as inches of Mercury

%I — Percent Isokinetic

K_p — Velocity pressure coefficient, 85.49 (ft/sec) [(lb/lb-mole) (in. Hg/°R) (1/in. H_2O)]$^{1/2}$

MW_s — Molecular Wt of gas sample, ($^{lb}/_{lb-mole}$)

MW_d — Molecular wt of dry flue gas, ($^{lb}/_{lb-mole}$)

MW_w — Molecular weight of water, (18 $^{lb}/_{lb-mole}$)

m_{PM} — Particulate matter mass, (grams)

$\%O_2$ — Percent of oxygen in flue gas by volume, dry basis

$\%CO_2$ — Percent of carbon dioxide in flue gas by volume, dry basis

$\%N_2$ — Percent of nitrogen in flue gas by volume, dry basis

P_{bar} — Absolute barometric pressure at sampling location, (in. Hg)

P_{std} — Standard absolute barometric pressure, (29.92 in. Hg)

P_{static} — Difference between stack gas pressure and P_{bar} (in. H_2O)

P_s — Absolute stack gas pressure, (in. Hg)

Δp — Velocity head reading at traverse point, (in. H_2O)

ppm — Parts per million

Q_a — Actual volumetric flow rate, at stack gas conditions (acfm)

Q_{std} — Volumetric flow rate at dry standard conditions (dscfm)

T_m — Absolute temp. of stack gas at meter (°R, avg. of meter inlet & outlet temps)

T_S — Absolute temperature of stack gas (°R)

θ — Total Sampling Time, minutes

v_s — Velocity of stack gas (ft/sec)

V_{lc} — Volume of liquid condensed in impingers and silica gel (grams or ml)

Vm — Dry gas volume measured by dry gas meter (cubic feet)

Vm_{std} — Dry gas volume measured by dry gas meter, standard conditions (dscf)

Vw_{std} — Volume of water vapor sampled, at standard conditions (cubic feet)

W — Width of duct

32 — Molecular weight of O_2, ($^{lb}/_{lb-mole}$)

44 — Molecular weight of CO_2, ($^{lb}/_{lb-mole}$)

28 — Molecular weight of N_2 ($^{lb}/_{lb-mole}$)

64.06 — Molecular weight of SO_2, ($^{lb}/_{lb-mole}$)

46.01 — Molecular weight of NOx, ($^{lb}/_{lb-mole}$)

17.64 — Conversion factor, (°R/in. Hg)

13.6 — Conversion factor, (in.H_2O/in. Hg)

460 — Conversion factor, (°F to °R)

0.0945 — Conversion factor for isokinetic calc.

10^6 — Conversion Factor, parts per million

385.3 — Conversion factor, ($^{dscf}/_{lb-mole}$)

15.43 — Conversion factor, ($^{grains}/_{gram}$)

7000 — Conversion factor, ($^{grains}/_{pound}$)

Sample Calculations – Run 1

Raw data is entered into spreadsheets to calculate results electronically. Calculations shown below use the spreadsheet generated results. Calculations with a calculator may not exactly match the results shown because of significant figures.

1. Circular Stack Area

$$A_s = \frac{\pi}{4}(D_s)^2 \qquad = \frac{\pi}{4}\left(\frac{144}{12}\right)^2 \qquad = 113.10\,ft^2$$

2. Absolute stack gas pressure

$$P_s = \left(P_{bar} + \frac{P_{static}}{13.6}\right) \qquad = \left((23.70) + \frac{-0.60}{13.6}\right) \qquad = 23.66\,in.Hg$$

3. Volume of dry gas sampled at standard conditions (29.92"Hg, 528°R)

$$Vm_{std} = \left(\frac{17.64(V_m)(P_b + \frac{\Delta H}{13.6})}{T_m}\right)(Y_d) = \left(\frac{17.64(61.435)(23.70 + \frac{1.87}{13.6})}{460 + 83}\right)(0.992) = 47.17\,dscf$$

4. Volume of water vapor collected at standard conditions

$$Vw_{std} = 0.04715V_{lc} \qquad = 0.04715(306.5) \qquad = 14.45\,scf$$

5. Proportion, by volume, of water vapor to dry gas, percent

$$B_{ws} = \frac{Vw_{std}}{(Vw_{std} + Vm_{std})} \qquad = \frac{14.45}{(14.45 + 47.17)} \qquad = 23.45\%$$

6. Dry molecular weight of stack gas

$$M_d = \left(\frac{44}{100}\right)\%CO_2 + \left(\frac{32}{100}\right)\%O_2 + \left(\frac{28}{100}\right)\%N_2 = 0.44(9.4) + 0.32(13.0) + 0.28(77.6) \qquad = 30.02\,\frac{lb}{lb-mole}$$

7. Actual molecular weight of stack gas

$$M_s = (1 - B_{ws})(M_d) + MW_w(B_{ws}) \qquad = (1 - 0.2345)(30.02) + 18(0.2345) \qquad = 27.20\,\frac{lb}{lb-mole}$$

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8. Velocity of stack gas

$$V_s = K_p (C_p) \sqrt{\Delta p} \, 60 \sqrt{\frac{T_s}{(P_s)(M_s)}} \qquad = 85.49(0.84)(0.6902)60\sqrt{\frac{(401+460)}{(23.66)(27.20)}} = 3,440 \frac{feet}{min\,ute}$$

9. Actual stack gas volumetric flow rate

$$Q_a = v_s (A_s) \qquad = 3440(113.10) \qquad = 389,040 \frac{cf}{min\,ute}$$

10. Stack gas volumetric flow rate at standard conditions

$$Q_{std} = \frac{17.64 Q_a P_s \left(1 - \frac{B_{ws}}{100}\right)}{(T_s)} \qquad = \frac{17.64(389,040)(23.66)\left(1 - \frac{23.45}{100}\right)}{(401+460)} \qquad = 144,340 \frac{dscf}{min\,ute}$$

11. Sampling Nozzle Area

$$A_n = \frac{\pi}{4}(D_n)^2 \qquad = \frac{\pi}{4}\left(\frac{0.304}{12}\right)^2 \qquad = 0.00050 \, ft^2$$

12. Percent of isokinetic sampling

$$\%I = \frac{0.09450 \, (T_s) Vm_{std}}{P_s v_s A_n \theta (1 - B_{ws})} \qquad = \frac{0.09450(401+460)(47.17)}{23.66\left(\frac{3440}{60}\right)(0.00050)80(1-0.2345)} \qquad = 91.7\%$$

13. Hydrogen Fluoride Concentration in gas (mg/m^3)

$$C_{HF} = \frac{(M_{HF})(35.316)}{(V_{mstd})}$$

$$C_{HF} = \frac{(0.123)(35.316)}{(47.17)}$$

$$C_{HF} = 0.092 \, mg / m^3$$

Where:

m_{HF}	hydrogen fluoride concentration (mg)
V_{mstd}	Dry gas volume measured by dry gas meter, standard conditions (dscf)
C_{HF}	Concentration of hydrogen fluoride

14. Hydrogen Fluoride Concentration (gr/dscf)

$$C_{gr/dscf} = \frac{(m_{HF})(0.01543)}{(V_{mstd})}$$

$$C_{gr/dscf} = \frac{(0.123)(0.01543)}{(47.17)}$$

$$C_{gr/dscf} = 0.000040\, gr/dscf$$

Where:

m_{HF}	hydrogen fluoride concentration (mg)
V_{mstd}	volume of gas sample, corrected to standard conditions (scf)
0.01543	conversion factor

15. Hydrogen Fluoride Concentration (ppm)

$$C_{ppm} = \frac{(C_{gr/dscf})(24.04)}{MW_{HF}}$$

$$C_{ppm} = \frac{(0.092)(24.04)}{20.00634}$$

$$C_{ppm} = 0.111\, ppm$$

Where:

C_{ppm}	hydrogen fluoride concentration (ppm)
$C_{gr/dscf}$	hydrogen fluoride concentration (gr/dscf)
MW_{HF}	molecular weight of hydrogen fluoride (lb/lb-mole)

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16. Hydrogen Fluoride Emission (lb/hr)

$$E_{lb/hr} = (0.01543)\left(\frac{M_{HF}}{V_{mstd}}\right)\left(\frac{60}{7000}\right)(Q_{std})$$

$$E_{lb/hr} = (0.01543)\left(\frac{60}{7000}\right)\left(\frac{0.123}{47.17}\right)(144340)$$

$$E_{lb/hr} = 0.050\, lb/hr$$

Where:

$E_{lb/hr}$	hydrogen fluoride emission (lb/hr)
M_{HF}	hydrogen fluoride mass
V_{mstd}	Dry gas volume measured by dry gas meter, standard conditions (dscf)
Q_{std}	volumetric flow rate of gas stream at standard conditions, dry basis (dscfm)

17. Hydrogen Fluoride Emission (lb/mmBtu, F_d Factor)

$$E_{lb/mmBtu} = \frac{(HF_{gr/dscf})(9780)(20.9)}{(7000)(20.9 - \%O_2)}$$

$$E_{lb/mmBtu} = \frac{(0.00004)(9780)(20.9)}{(7000)(20.9 - 13.0)}$$

$$E_{lb/mmBtu} = 0.000149\, lb/mmBtu$$

Where:

$E_{lb/mmBtu}$	hydrogen fluoride emission (lb/mmBtu)
$HF_{gr/dscf}$	hydrogen fluoride concentration in gas (gr/dscf)
20.9	oxygen concentration in ambient air (%)
$\%O_2$	average concentration of oxygen for the test run (%)

APPENDIX E

LABORATORY DATA

Optimal Air Testing Services

9971 W. Landmark Lane
Casper, WY 82604

Solvay Chemical
Client Project #1301A

Analytical Report
(0413-135)

EPA Method 26A
Hydrogen fluoride

Enthalpy Analytical, Inc.

Phone: (919) 850 - 4392 / Fax: (919) 850 - 9012 / www.enthalpy.com
800-1 Capitola Drive   Durham, NC 27713-4385

I certify that to the best of my knowledge all analytical data presented in this report:
- Have been checked for completeness
- Are accurate, error-free, and legible
- Have been conducted in accordance with approved protocol, and that all deviations and analytical problems are summarized in the appropriate narrative(s)

This analytical report was prepared in Portable Document Format (.PDF) and contains 61 pages.

QA Review Performed by: Michael Steven Schapira

Report Issued: 4/29/13

Summary of Results

Company	OATS	
Analyst	EDE	
Parameters	EPA Method 26A	

Client #	1301A	
Job #	0413-135	
# Samples	3, 2 Blanks	

Compound	Sample ID / Catch Weight (ug)		
	SC-M26A-R1-H2SO4	**SC-M26A-R2-H2SO4**	**SC-M26A-R3-H2SO4**
Hydrogen fluoride	123 ND	126 ND	128 ND
	RB-1-H2SO4	**RB-2-Water**	
Hydrogen fluoride	45.1 ND	45.5 ND	

Results

Client #	1301A
Job #	0413-135
# Samples	3, 2 Blanks

Lower Curve Limit 0.200 (ug/mL)
Upper Curve Limit   10.0 (ug/mL)

e as fluoride

D	Lab ID # 2	Analysis Method	Ret Time (min)	Ret Time (min)	% Diff Ret	Conc # 1 (ug/mL)	Conc # 2 (ug/mL)	% Diff Conc	Avg Conc (ug/mL)	DF	Vol (mL)	Conv. Factor	Catch Weight (ug)	Qual
01.D	051-2002.D	HPLC72PG111.M	NA	NA	NA	0.0200	0.0200	0.0	0.0200	10	586	1.053	123	ND
01.D	054-2302.D	HPLC72PG111.M	NA	NA	NA	0.0200	0.0200	0.0	0.0200	10	600	1.053	126	ND
01.D	055-2402.D	HPLC72PG111.M	NA	NA	NA	0.0200	0.0200	0.0	0.0200	10	610	1.053	128	ND
01.D	056-2502.D	HPLC72PG111.M	NA	NA	NA	0.0200	0.0200	0.0	0.0200	10	214	1.053	45.1	ND
01.D	057-2602.D	HPLC72PG111.M	NA	NA	NA	0.0200	0.0200	0.0	0.0200	10	216	1.053	45.5	ND
01.D	007-0902.D	HPLC72PG111.M	3.04	3.05	0.1	5.01	5.05	0.3	5.03	1	10.0	1.053	53.0	

Spike Amount (ug) 52.7
Spike Recovery (%) 101%

| 01.D | 008-1002.D | HPLC72PG111.M | 2.97 | 2.97 | 0.0 | 5.12 | 5.13 | 0.1 | 5.12 | 1 | 10.0 | 1.053 | 54.0 | |

Spike Amount (ug) 52.7
Spike Recovery (%) 102%

4/29/2013

Lower Curve Limit 0.200 (ug/mL)
Upper Curve Limit   10.0 (ug/mL)

e as fluoride

Lab ID # 2	Analysis Method	Ret Time (min)	Ret Time (min)	% Diff Ret	Conc # 1 (ug/mL)	Conc # 2 (ug/mL)	% Diff Conc	Avg Conc (ug/mL)	DF	Vol (mL)	Conv. Factor	Catch Weight (ug)	Qual
009-1102.D	HPLC72PG111.M	NA	NA	NA	0.0200	0.0200	0.0	0.0200	1	1.00	1.053	0.0211	ND

Lab ID # 2	Analysis Method	Ret Time (min)	Ret Time (min)	% Diff Ret	Conc # 1 (ug/mL)	Conc # 2 (ug/mL)	% Diff Conc	Avg Conc (ug/mL)	DF	Vol (mL)	Conv. Factor	Catch Weight (ug)	Qual
052-2102.D	HPLC72PG111.M	3.05	3.05	0.2	3.06	3.10	0.6	3.08	1	10.0	1.053	32.4	

Spike Amount (ug)	31.6
Native Amount (ug)	0.00
Spike Recovery (%)	103%

Lab ID # 2	Analysis Method	Ret Time (min)	Ret Time (min)	% Diff Ret	Conc # 1 (ug/mL)	Conc # 2 (ug/mL)	% Diff Conc	Avg Conc (ug/mL)	DF	Vol (mL)	Conv. Factor	Catch Weight (ug)	Qual
053-2202.D	HPLC72PG111.M	3.05	3.05	0.0	3.10	3.10	0.0	3.10	1	10.0	1.053	32.6	

Spike Amount (ug)	31.6
Native Amount (ug)	0.00
Spike Recovery (%)	103%

Narrative Summary

Enthalpy Analytical Narrative Summary

Company	Optimal Air Testing Services
Analyst	EDE
Parameters	EPA Method 26A

Client #	1301A
Job #	0413-135
# Samples	3, 2 Blanks

Custody   Chester Burnett received the samples on 4/24/13 after being relinquished by Optimal Air Testing Services. The samples were received at 14.6°C and in good condition. Prior to, during, and after analysis, the samples were kept under lock with access only to authorized personnel by Enthalpy Analytical, Inc.

Analysis   The samples were analyzed for fluoride using the analytical procedures in EPA Method 26A, Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources Isokinetic Method (40 CFR Part 60, Appendix A).

The samples were analyzed following the procedures in Section 11.0, Analytical Procedures. All samples and standards are prepared, stored, and analyzed using high-density polyethylene containers.

The Metrohm 861 Compact IC ("Smithers" S/N 1861002007189) was equipped with a Metrohm 861 Conductivity Detector and a Metrosep A Supp 5 - 110/4.0mm (S/N # 7908297) column.

Calibration   The calibration curve is located in the back of this report and referenced in the Analysis Method column on the Detailed Results page.

For each calibration curve used, the first page of the curve contains all method specific parameters (i.e., curve type, origin, weight, etc.) used to quantify the samples. The calibration curve section also includes a table with the Retention Time (RetTime), Level (Lvl), Amount (corresponding units), Area, Response Factor (Amt/Area) and the analyte Name. The calibration table is used to identify (by retention time) and quantify each target compound.

Chromatographic Conditions   The acquisition method Metrohm.M is included in the Calibration Curve Chromatograms section of this report.

QC Notes   The samples were analyzed within the holding time specified by the method.

The analyses of the laboratory reagent blanks or client blanks contained no fluoride at concentrations greater than the detection limit.

Enthalpy Analytical Narrative Summary
(continued)

QC Notes (continued)

Duplicate matrix spikes were prepared using aliquots of sample *SC-M26A-R1-H2SO4* and both exhibited spike recovery values of 103%.

Laboratory Control Samples (LCS) were analyzed along with the samples. The recovery values were 101% and 102%.

Reporting Notes

The sulfuric acid matrix samples were analyzed for fluoride but are reported as hydrogen fluoride. The results were converted using a conversion factor of 1.028 to account for the additional hydrogen mass.

The results presented in this report are representative of the samples as provided to the laboratory.

General Reporting Notes

The following are general reporting notes that are applicable to all Enthalpy Analytical, Inc. data reports, unless specifically noted otherwise.

- Any analysis which referrs to the method as *"Type"* represents a planned deviation from the reference method. For instance a Hydrogen Sulfide assay from a Tedlar bag would be labeled as "EPA Method 16-Type" because Tedlar bags are not mentioned as one of the collection options in EPA Method 16.

- The acronym *MDL* represents the Minimum Detection Limit. Below this value the laboratory cannot determine the presence of the analyte of interest reliably.

- The acronym *LOQ* represents the Limit of Quantification. Below this value the laboratory cannot quantitate the analyte of interest within the criteria of the method.

- The acronym *ND* following a value indicates a non-detect or analytical result below the MDL.

- The letter *J* in the Qualifier or Flag column in the results indicates that the value is between the MDL and the LOQ. The laboratory can positively identify the analyte of interest as present, but the value should be considered an estimate.

- The letter *E* in the Qualifier or Flag column indicates an analytical result exceeding 100% of the highest calibration point. The associated value should be considered as an estimate.

- The acronym *DF* represents Dilution Factor. This number represents dilution of the sample during the preparation and/or analysis process. The analytical result taken from a laboratory instrument is multiplied by the DF to determine the final undiluted sample results.

- The addition of *MS* to the Sample ID represents a Matrix Spike. An aliquot of an actual sample is spiked with a known amount of analyte so that a percent recovery value can be determined. The MS analysis indicates what effect the sample matrix may have on the target analyte, i.e. whether or not anything in the sample matrix interferes with the analysis of the analyte(s).

- The addition of *MSD* to the Sample ID represents a Matrix Spike Duplicate. Prepared in the same manner as an MS, the use of duplicate matrix spikes allows further confirmation of laboratory quality by showing the consistency of results gained by performing the same steps multiple times.

- The addition of *LD* to the Sample ID represents a Laboratory Duplicate. The analyst prepares an additional aliquot of sample for testing and the results of the duplicate analysis are compared to the initial result. The result should have a difference value of within 10% of the initial result (if the results of the original analysis are greater than the LOQ).

- The addition of *AD* to the Sample ID represents an Alternate Dilution. The analyst prepares an additional aliquot at a different dilution factor (usually double the initial factor). This analysis helps confirm that no additional compound is present and coeluting or sharing absorbance with the analyte of interest, as they would have a different response/absorbance than the analyte of interest.

- The Sample ID *LCS* represents a Laboratory Control Sample. Clean matrix, similar to the client sample matrix, prepared and analyzed by the laboratory using the same reagents, spiking standards and procedures used for the client samples. The LCS is used to assess the control of the laboratory's analytical system. Whenever spikes are prepared for our client projects, two spikes are retained as LCSs. The LCSs are labeled with the associated project number and kept in-house at the appropriate temperature conditions. When the project samples are received for analysis, the LCSs are analyzed to confirm that the analyte could be recovered from the media, separate from the samples which were used on the project and which may have been affected by source matrix, sample collection and/or sample transport.

General Reporting Notes

(continued)

- **Significant Figures**: Where the reported value is much greater than unity (1.00) in the units expressed, the number is rounded to a whole number of units, rather than to 3 significant figures. For example, a value of 10,456.45 ug catch is rounded to 10,456 ug. There are five significant digits displayed, but no confidence should be placed on more than two significant digits.

- **Manual Integration**: The data systems used for processing will flag manually integrated peaks with an "M". There are several reasons a peak may be manually integrated. These reasons will be identified by the following two letter designations. The peak was *not integrated* by the software "**NI**", the peak was *integrated incorrectly* by the software "**II**" or the *wrong peak* was integrated by the software "**WP**". These codes will accompany the analyst's manual integration stamp placed next to the compound name on the chromatogram.

Sample Custody

ody

er, Wyoming 82604
307) 237-0961

4/24/13 Date	Contents	Containers	HF		Volume		Comments
-1 4/19/2013	0.1 N H2SO4	2	X		X		
-1 4/19/2013	0.1 N H2SO4	2	X		X		
-1 4/19/2013	0.1 N H2SO4	2	X		X		
4/19/2013	0.1 N H2SO4	1	X				
4/19/2013	Water	1	X				

ndix A Method 26A

e call to discuss quick turnaround)

ear minimum detection limits

		Receive		Relinquish		
		Date	Time	Date	Time	Affiliation
Dan Klassen	DK			4/22/2013	10:00	OATS
Justin Russell	JR	4/22/2013	11:00			
Chester Burnett		4-24-13	10:35A			

Temp= 14.6°C
Ray Gun #1

EA Job # 0413-135 Page 14 of 61

APPENDIX F

PROCESS DATA

AQD #17 "A" Calciner
(CA-1/EP-1)
DATE: 4/19/13
OPERATIONAL DATA

	Run #1	Run #2	Run #3	Average
Start Time	10:44	12:25	14:08	
Stop Time	12:11	13:58	15:30	
Production Rate TPH	104	105	108	105.7
Opacity	0.4	0.3	0.2	0.3
Coal Consumption TPH	5.6	5.6	5.6	5.6

PRECIPITATOR DATA

	Run #1	Run #2	Run #3
FIELD 1			
SECONDARY VOLTAGE kV	0	0	0
SECONDARY CURRENT mA	0	0	0
FIELD 2			
SECONDARY VOLTAGE kV	34	35	34
SECONDARY CURRENT mA	161	154	154
FIELD 3			
SECONDARY VOLTAGE kV	31	32	21
SECONDARY CURRENT mA	1384	1389	1388
FIELD 4			
SECONDARY VOLTAGE kV	30	30	30
SECONDARY CURRENT mA	1352	1355	1357
FIELD 5			
SECONDARY VOLTAGE kV	29	30	30
SECONDARY CURRENT mA	1311	1312	1315
FIELD 6			
SECONDARY VOLTAGE kV	0	0	0
SECONDARY CURRENT mA	0	0	0

AQD #17 "B" Calciner
(CA-2/EP-2)
DATE: 4/19/13
OPERATIONAL DATA

	Run #1	Run #2	Run #3	Average
Start Time	10:44	12:25	14:08	
Stop Time	12:11	13:58	15:30	
Production Rate TPH	98	97	106	100.3
Opacity	0.4	0.3	0.2	0.3
Coal Consumption TPH	5.6	5.6	5.6	5.6

PRECIPITATOR DATA

	Run #1	Run #2	Run #3
FIELD 1			
SECONDARY VOLTAGE kV	29	28	29
SECONDARY CURRENT mA	174	165	166
FIELD 2			
SECONDARY VOLTAGE kV	32	32	32
SECONDARY CURRENT mA	1377	1379	1376
FIELD 3			
SECONDARY VOLTAGE kV	32	32	32
SECONDARY CURRENT mA	1402	1401	1379
FIELD 4			
SECONDARY VOLTAGE kV	26	26	25
SECONDARY CURRENT mA	395	404	404
FIELD 5			
SECONDARY VOLTAGE kV	30	30	30
SECONDARY CURRENT mA	1399	1400	1400
FIELD 6			
SECONDARY VOLTAGE kV	0	0	0
SECONDARY CURRENT mA	0	0	0